

THE AMERICAN MINERALOGIST

JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 7

JANUARY, 1922

No. 1

A SO-CALLED BORNITE-CHALCOPYRITE INTERGROWTH

FROM LEGATE CREEK, PACIFIC, B. C.

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During a geological investigation of the M. & K. copper property, fifteen miles up Legate Creek from Pacific, B. C., the writer's attention was attracted by the interesting and rather unusual association of the ore minerals. This association consists of a somewhat intimate mixture of bornite, galenite and chalcopyrite occurring as solid masses in the basins of drag folds in a series of Jurassic lavas and tuffaceous sediments. Bornite and galenite are the most persistent minerals, and form the typical ore. The chalcopyrite, which is of the very fine-grained dense variety, occurs in branching veinlets and thin finger-like masses cutting thru solid masses of the other two minerals. The field evidence strongly suggests replacing relations for the chalcopyrite; and in order to obtain more detailed evidence regarding the paragenesis of the minerals, several specimens were collected, and their polished surfaces were submitted to mineragraphic examination. This paper has to do with the relation of the bornite and chalcopyrite as disclosed by this examination.

The polished surfaces show the presence of four metalliferous minerals—bornite, galenite, chalcopyrite and sphalerite. Bornite and galenite are most consistently present (as noted in the field). Sphalerite occurs sporadically in scattered grains. Chalcopyrite is characteristically absent from certain portions of the ore, while in other portions it is very abundant. Covellite occurs as narrow veinlets cutting all the other minerals of the sections (Fig. 4) and as an alteration product of the bornite (Figs. 1 and 2).

Under a magnification of 100 diameters the bornite appears to be homogeneous. Continued intensive examination of sections of this mineral brings into view a maze of minute lighter colored inclusions but these are so small that only the merest suggestion



Fig 1—Showing the characteristic "intergrowth" and the development of chalcopyrite needles as apophyses from larger masses of chalcopyrite.

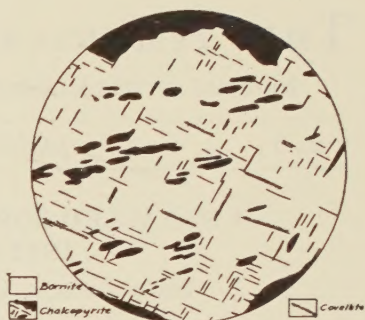


Fig 2—Showing the unequal development of the chalcopyrite needles and lenticles along 3 of the directions of cleavage of the barite.



Fig 3—Showing the triangular pattern produced by the nearly equal development of the "intergrowth" in 3 directions.



Fig 4—Showing the development of finger-like masses of chalcopyrite with rectilinear extensions parallel to the orientation of the chalcopyrite needles.

of their character may be obtained. On raising the magnification to 800 diameters, the inclusions take the form of needles or lenticles oriented as shown in the accompanying sketches.

These sketches are camera lucida drawings and accurately represent the positions and shapes of the various minerals for the magnification under which they were drawn. Owing to the difficulty of making accurate drawings with a magnification of 800, this was reduced to 500 diameters, and the sketches were then made. The magnification was further reduced to 250 diameters during the process of reproduction. It is to be noted that the field of the microscope and the mineral patterns as seen thru the microscope appear very much smaller than the corresponding features after they are drawn by the camera lucida method. Consequently the sizes of the mineral grains appear much larger in the sketches as reproduced than they do to the eye of the observer with a magnification of 500.

The "intergrowths" have the following characteristics:

- (1) The main field or groundmass is always bornite.
- (2) The needles or lenticles are always chalcopyrite.
- (3) In the case of some grains of bornite, the section is so cut that the chalcopyrite needles are arranged in two linear sets nearly at right angles to each other (Figs. 1 and 4).
- (4) In other cases, there are three linear sets of chalcopyrite needles nearly equally developed and occupying three zones at about 60° to one another. (Fig. 3.)
- (5) In other places, two sets of needles intersect at nearly 90° , while a set of rather thick lenticles, more broadly spaced than the needles, occupies some linear position between the two sets of needles. (Figs. 1 and 2.)
- (6) In several cases the needles and lenticles of chalcopyrite appear as apophyses or offshoots from some larger mass of the mineral (Fig. 1.)
- (7) Covellite occurs along the borders of the chalcopyrite needles and lenticles, with sharp boundaries against the chalcopyrite and in gradation contact with the bornite. (Figs. 1 and 2.)

From the above characteristics, the "intergrowths" are interpreted by the writer as replacements of bornite along its octahedral cleavage planes by chalcopyrite, and not as simultaneous (or eutectic) intergrowths for the following reasons:

- (1) There is a very marked lack of uniformity in the ratio of chalcopyrite to bornite in the "intergrowth."
- (2) If the "intergrowth" were of eutectic character, one would hardly expect both chalcopyrite and bornite to be present, isolated from the "intergrowth" and occurring as separate homogeneous developments.
- (3) The number of chalcopyrite needles and lenticles is increased very considerably in those specimens which contain larger masses of the mineral. In cases where larger masses of chalcopyrite are absent the areas of bornite are homogeneous and free of the "intergrowth." This suggests that in some way the presence of needles and lenticles is related to the occurrence of larger masses of chalcopyrite.
- (4) The relationship suggested immediately above is manifested in Fig. 1, where needles of chalcopyrite are found as small offshoots or apophyses from larger masses of the mineral. These apophyses have the same orientation as the rest of the needles, which suggests

that the presence of the needles is one of the early phases of the replacement of bornite by chalcopyrite.

(5) Fig. 4 illustrates one of the common relationships between the two minerals. Here finger-like masses of chalcopyrite show an elongation and somewhat rectilinear outlines parallel to the orientation of the two sets of needles. This case exemplifies one of the later stages in the replacement of the bornite, which is interpreted as the development of the finger-like masses by the enlargement and coalescence of the chalcopyrite needles with the retention in general of an orientation parallel to the cleavage planes of the bornite.

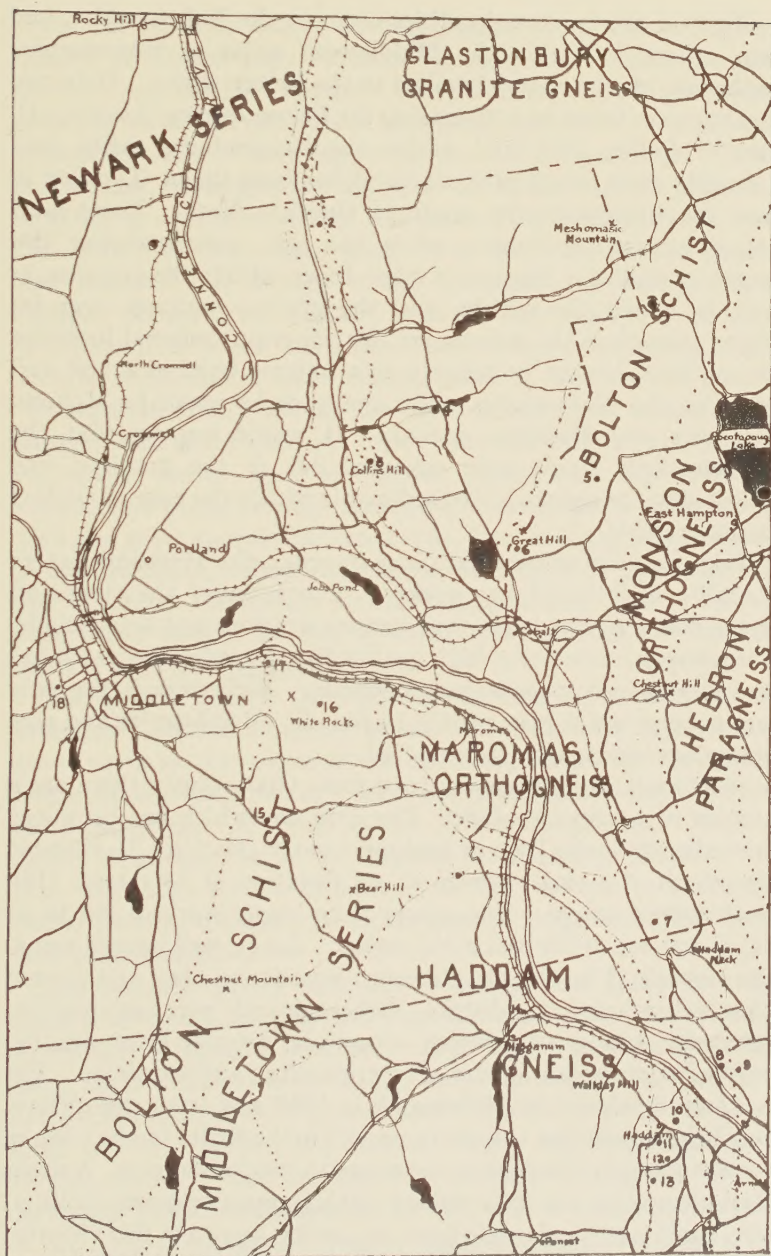
The mineragraphic evidence, therefore, seems to substantiate the field evidence that chalcopyrite is replacing bornite; and it also draws attention to one other case of the lack of homogeneity of the mineral bornite.

MINERAL LOCALITIES IN THE VICINITY OF MIDDLETOWN, CONNECTICUT

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A few of the pegmatite quarries in the vicinity of Middletown, from which minerals have been taken in the past, are still being worked. Many others have been abandoned, and their locations may be lost, if a permanent record is not somewhere preserved. It was with this thought in mind that the following paper was written.

Of the many feldspar prospect-holes opened in Middlesex and adjacent portions of Hartford counties, Connecticut, fourteen may be selected as more or less famous for the minerals they have produced. The entire group lie within a radius of 14 kilometers (9 miles) of Wesleyan University (Locality 18, Fig. 1). The Connecticut pegmatite dikes are composed of predominating quartz and perthitic feldspar with some muscovite and biotite. Most of the gem minerals occur in pockets from a few centimeters to over one meter in diameter. Some of the larger pockets have shown quartz crystals 6 decimeters long, and 3 decimeters in diameter. Perthite crystals with well developed planes have equalled the quartz in their dimensions. These minerals project from the walls of the cavities, and are covered by platy crystals of cleavelandite which form a background for the rarer minerals.



Eight of the fourteen localities occur in the Bolton schist, and four others lie within the Middletown series of metamorphic sediments which are closely allied to the Bolton schist. Only two localities are found in orthogneiss, the Pelton quarry (Locality 4), east of Collins Hill and within the Glastonbury gneiss, and a locality from which precious beryl has been taken (Locality 9) near the Gillette quarry, south of Haddam Neck. These facts attain greater significance when the map accompanying this paper is studied. Pegmatite dikes occur within the gneisses, as well as within the schists, and the gneisses outcrop over far larger areas than the schists, yet the important mineral localities are confined almost exclusively to a narrow band of schist surrounding the Glastonbury gneiss and lying between the Monson, Maromas and Haddam gneisses. It would appear that the pneumatolytic fluids were squeezed out of the granites, and collected in the tightly folded sediments within the zone of contact metamorphism.

Taking up the mineral localities in order, the Husband quarry (Locality 1) is still being worked. A number of the older and larger pits are abandoned, but new excavations are being made. The feldspar is rated as of high quality by the trade, and yet it has proved relatively poor in rare minerals. Torbernite is the only rare mineral which may readily be found. Molybdenite and rose quartz are occasionally encountered.

Southward along the state road from Glastonbury there are a number of quarry openings. The only one which has produced rare minerals is the Hale or Andrews quarry (Locality 2), situated just south of a small stream at an elevation of 55 meters (180 feet) approximately. The quarry is no longer worked, but in its day it was one of the best in the region. Large, well formed monazite crystals (2 to 3 cm. in diameter) were found here, and are not known elsewhere in the district. Other minerals were molybdenite, sphalerite, rose quartz, zircon, columbite, massive green apatite, purple heterosite (secondary after triphylite), and uraninite. The uraninite analyzed by Hillebrand¹ in 1889 was from this quarry. It will be noted that the quarry is within the limits of the town of Portland, not in Glastonbury as stated in most references. A single blast about the year 1884 yielded 100 kilograms or more of columbite, the largest single yield from one pocket known in this vicinity. The entire mass was without crystalline planes.

¹ *Bull. U. S. Geol. Surv.* No. 78, 43, 1891.

Of the quarries active at the present time, the Strickland quarry at Collins Hill, Portland (Locality 3), is the most productive, and the best known.² Mr. F. E. Strickland, the owner, is an expert on the minerals of his quarry, and saves carefully any unusual crystals. The quarry was opened as early as 1840. There is a pitcher, bearing in gilt the name of Strickland, now preserved in Wesleyan Museum, which was made from feldspar taken from the quarry at that early date. For many years the quarry was inactive, but recently it has produced the best grade of feldspar known in the region. It is the only quarry in this part of Connecticut which has yielded asbestiform tourmaline, purple apatite, lithiophilite, and nailhead calcite. The greater part of the uraninite from Portland has come from a small area near the hanging wall of the quarry. Other minerals reported are sphalerite, pyrite, smoky, rose, and citrine quartz, pink (caesium) and aquamarine beryl, garnet, microcline, cleavelandite, spodumene, pink and green tourmaline, muscovite, biotite, lepidolite, cookeite, pinite, kaolinite, columbite, purple, and massive green apatite, and autunite. While not strictly a pegmatite mineral, iolite has been found within the Bolton schist a few centimeters from its contact with the pegmatite.

The Pelton quarry (Locality 4) has long been inactive. It probably produced a number of rare minerals in its day, but it is now known as the source of two minerals, unique for the region, bismutite and samarskite. Beryl and crystals of muscovite from the locality may be found in the Wesleyan museum. Another quarry long inactive is the Nathan Hall quarry (Locality 5). It is still noted for the abundance of the rose quartz to be obtained from its dumps. No other quarry compares with it in its yield of this mineral.

The Swanson quarry (Locality 7) lies far back from the road, along a cart-path leading east from the main road past the relatively new Swanson homestead. It is a road (not shown on the map) which follows the township line. Although the opening is not worked now, there is a great deal of lepidolite to be found, and some triplite. Within the district triplite has been found only at this quarry. The mineral is intimately intergrown with a dark blue, massive tourmaline. It was with the expectation that

² An article on this locality, by Earl V. Shannon, has already appeared in this magazine: *Am. Min.*, 5 (3), 51-54, 1920.

the lepidolite might be shipped to Germany as a source of lithium that the quarry was opened, just before the war. It is reported that shipments got no farther than the dock.³

The Gillette quarry (Locality 8) may be reached by automobile from Portland or Cobalt, but is probably more easily found by crossing the river from the Valley Division of the New York, New Haven, and Hartford railroad, leaving the train at Haddam, and taking a little used ferry directly to the quarry. The Haddam Neck locality, by which is usually meant the Gillette quarry, is one of the best known mineral localities in the United States. The quarry was abandoned a number of years ago because it had been worked to such a depth that it was impossible to keep out water. It was worked for a time by a New York jewelry company for its gem tourmalines. It is said that the last blast made by Mr. Gillette revealed a gem pocket from which tourmalines were taken which were sold to a New York museum for \$700. Green, pink, "watermelon," and yellow varieties of tourmaline are known from the locality. Other minerals discovered are red fluorite, smoky quartz, microcline, albite, golden, pink (caesium) and aquamarine beryl, muscovite, biotite, lepidolite, cookeite, microlite, and white apatite. The muscovite is unique in that it occurs as sheaf-like aggregates of fibrous, columnar crystals, 4 cm. in diameter and 2 cm. in length. The crystals are attached by a small area at the side, and are so compact that an analysis was made before the determination was established. At present there is little to be found at the quarry.

On the hillside east of the Gillette quarry, and slightly south of a building stone quarry in the Monson gneiss from which blocks for the construction of Fort Hamilton in New York harbor were obtained, there was opened, 30 or 40 years ago, a pocket-like depression from which a number of valuable aquamarines were taken. The depression (Locality 9) was only a meter or two across, and is now overgrown with brush. The aquamarines were peculiar in that the greater part of the crystals were not of gem quality. Five millimeters or less from their tops they became clear and beautifully colored. A few of the crystals may be found in old collections.

On the west side of the river in the vicinity of the village of Haddam, there are a number of old mineral localities. Mr. E. W.

³ Compare Shannon, *Am. Min.* 5 (4), 82-84, 1920.

Hazen of Haddam kindly conducted Professor W. N. Rice and the writer to several of the openings last summer. One of the chance finds of the region was made in a roadside quarry, later used as a cellar (Locality 10). A number of chrysoberyls and garnets were unearthed, but there is no record that other minerals were found. The house built over the site was later removed. No further attempts were made to obtain more minerals.

On the hill across the road from this locality there is an abandoned quarry on land owned by Mr. Hazen (Locality 11) from which small plates of autunite may be obtained. Following the pegmatite ridge southward the Haddam epidote locality is reached. (Locality 12). A number of old collections have well crystallized specimens of clear epidote from this opening. There is a blast hole at the foot of a steep slope facing toward the east where the pegmatite dike dips beneath the meadow. With pick and shovel the moss and rubble were removed, and a limestone was disclosed in contact with the pegmatite. At the contact the limestone is transformed to epidote and garnet. Pockets of the more finely crystallized epidote are included in the more massive material. There have been no transparent crystals found at the locality for a number of years.

The road which lies to the south of the epidote locality leads toward the west and crosses a small brook. A hundred meters or so beyond the brook one climbs to the crest of a pegmatite ridge. Going southward along the crest for two hundred meters, one comes to the Tims Hill Locality (Locality 13). Associated with the contact of the Haddam gneiss with the Middletown series there is a peculiar type of pegmatite consisting of oligoclase, biotite, short, doubly terminated black tourmalines (5 to 10 mm. in length), and crystallized iolite showing alteration to fahlunite. Gahnite and allanite are also reported from the locality. Professor Rice and the writer attempted to relocate the blast hole from which the iolite came, but without success. Professor Rice had visited the locality many years ago, and had detailed notes on its situation. It was very apparent that we were in the immediate vicinity, but no trace of the peculiar pegmatite could be obtained.

There are a large number of quarry openings along the state highway between Middletown and Haddam. None of them, however, is known to have produced rare minerals, except the Toll Gate quarry (Locality 15). The opening has been long since

abandoned, and is fast being overgrown. It is situated slightly north of the highway. The road cuts across the southern end of the dike in making an abrupt turn to the southeast. In addition to the usual tourmalines and beryls, the quarry is known for the large size of a number of columbite crystals which were taken from it many years ago.

The ridge of pegmatite dikes through which the Connecticut river has cut in passing from the Newark sandstones to the crystalline rocks of the Eastern Highland is a prominent feature in the landscape as one looks eastward from Middletown. The ridge is known locally as White Rocks. Somewhat east of the ridge most conspicuous from Middletown, and south of the river, there is a feldspar quarry (Locality 16) which has been intermittently worked for a number of years. The locality is not especially rich in rare minerals, but occasionally odd varieties of the pegmatite types may be found. Opaque pink and green tourmalines may now be obtained. Lepidolite, uraninite, zircon, columbite, large, opaque beryls, microlite, and garnet are other minerals reported from the locality in the past.

CHARACTER OF THE PEGMATITIC INTRUSIONS

It may not be out of place to make a brief statement concerning the method of intrusion of the pegmatite dikes into the Bolton schist. The exposures at the Strickland quarry are interesting in making clear the character of the intrusions. The bodies are not, usually, cross-cutting as would be inferred by the use of the term "dike." The magma, while still in a fluid or viscous condition, seems to have been folded into the pliant schist, as putty is folded into the rolls of the paper in which it is contained. Thus, while the magma was intruded during the Appalachian mountain-building of New England, it crystallized after that event, and has not been rendered schistose by any subsequent movements. The shattering of the walls of some of the gem-pockets in the pegmatite tells of violent disturbances by earthquake movements, and the recementation of the fragments by pneumatolytic minerals, such as tourmaline and apatite, indicates that openings have allowed gases to escape from deep-seated sources. But there have been no crushing movements to metamorphose the pegmatites as a whole.

MINERAL LOCALITIES NOT PEGMATITIC IN ORIGIN

There are two or three mineral localities in the vicinity of Middletown which are not associated with pegmatite dikes. The best known of these is the Old Silver Mine, situated approximately three kilometers east of the center of the city (Locality 17). During the Revolutionary War the mine was worked for lead, which was fashioned into bullets. Slash veins occur in the crush zone along the great fault between the Bolton schist and the Triassic conglomerates. The minerals found are galenite, sphalerite, pyrite, marcasite, chalcopyrite, quartz, calcite, and fluorite. The pyrite is frequently found in cubes, elongated parallel to one axis. Dana describes it as "capillary" pyrite, but the diameter of the rods is generally too large for such an appellation.

South of Great Hill, north of Cobalt (Locality 6), at an elevation of approximately 450 feet, disseminated masses of chloanthite, and niccolite are found in the Bolton schist. Arsenopyrite and löllingite are found in quartz veins associated closely with the cobalt minerals. The locality has been worked over so frequently that there are few specimens to be obtained at present.⁴

In the bed of the brook north of the village of Higganum (Locality 14) well formed magnetite crystals occur in red pegmatite in the Haddam gneiss. The occurrence is only interesting in that such perfect crystals of magnetite are rare in the district.

RÉSUMÉ

The following is a list of thirty-eight minerals which have been reported from the pegmatite dikes in the vicinity of Middletown, Connecticut.

Molybdenite,	Microcline,	Tourmaline,	Monazite,
Sphalerite,	Albite, -	Muscovite,	Apatite, -
Pyrite,	Oligoclase,	Biotite,	Triplite,
Fluorite,	Spodumene,	Pinite,	Lithiophilite,
Quartz,	Beryl,	Lepidolite,	Triphylite,
Magnetite,	Iolite,	Cookeite,	Torbernite,
Gahnite,	Garnet,	Kaolinite,	Autunite,
Chrysoberyl,	Zircon,	Microlite,	Uraninite.
Calcite,	Epidote,	Columbite,	
Bismutite,	Allanite,	Samarskite,	

⁴ Shannon, *Am. Min.* 6 (5), 88-90, 1921.

Seven other minerals are found, either at the Great Hill locality, Cobalt, or at the Old Silver Mine. The list includes the following minerals, making a total of forty-five more or less rare minerals from the region, of which twenty-two have been found at the Strickland quarry.

Chloanthite,	Galenite,	Arsenopyrite,	Chalcopyrite.
Niccolite,	Marcasite,	Löllingite,	

A STUDY OF THE CONSTITUTION OF THAUMASITE

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The empirical formula of thaumasite has been shown by several analyses to be $\text{CaCO}_3 \cdot \text{CaSO}_4 \cdot \text{CaSiO}_3 \cdot 15\text{H}_2\text{O}$. Penfield and Pratt¹ considered the mineral a silicate, but Wherry² has shown it to be more probably a sulfate, crystallographically related to connellite and hanksite. He points out that at the West Paterson locality the thaumasite has been formed by the action upon anhydrite of solutions capable of depositing calcite and zeolites. Penfield and Pratt made a study of the rate of dehydration of the mineral, and concluded that it contained thirteen molecules of water and four hydroxyl groups. A later study of the dehydration curve by Merwin³ indicated fourteen molecules of water and two hydroxyl groups. Wherry's interpretation fits in best with the latter.

This paper is an attempt to decide between these interpretations of the water content, by means of the theory of molecular refractivity, which affirms that the molecular refractivity of a compound is equal to the sum of that of its components.⁴ While this theory was developed with especial reference to organic liquids, it also holds well for inorganic solids;⁵ and altho the crystallinity and consequent anisotropism may affect its applicability slightly, the deviation is not enough to vitiate the results arrived at in a study such as the present one.

¹ Penfield, S. L., and Pratt, J. H.: *Am. J. Sci.*, (4), 1, 229, 1896.

² Wherry, E. T.: *Proc. U. S. Nat. Mus.*, 54, 373, 1918.

³ Merwin, H. E.: *J. Wash. Acad. Sci.*, 4, 494, 1914.

⁴ The refractivities are preferably calculated by the Lorentz-Lorenz formula:

$$R = \frac{n^2 - 1}{n^2 + 2} \cdot \frac{M}{d}$$
 where n is the mean index of refraction, M the molecular weight, d the specific gravity, and R the molecular refractivity.

⁵ Pope, W. J.: *J. Chem. Soc.*, 69, 1530, 1896.

The molecular refractivities of CaCO_3 , CaSO_4 , CaSiO_3 and H_2O were calculated from the observed specific gravity and mean refractive index (for sodium light) of calcite, anhydrite, wollastonite, and water. The calcite value was used in place of the slightly lower aragonite value because of the close association of thaumasite and calcite, which seems to indicate a relation in constitution, as far as the carbonate portion of the thaumasite molecule is concerned. Similarly the value for calcium metasilicate was used, since thaumasite is associated with zeolites, prevailingly metasilicates. For the molecular refractivities of hydroxyl, oxygen, and hydrogen, Eisenlohr's values⁶ for sodium light were used. All these values are given in Table I, in which is included the molecular refractivity of thaumasite, as calculated from the mean of all published values for its specific gravity and refractive index.⁷

TABLE I

Compound	Molecular weight	Specific gravity	Mean refractive index	Molecular refractivity
CaSO_4	136.13	2.96	1.586	15.43
CaCO_3	100.07	2.72	1.601	12.60
CaSiO_3	116.37	2.91	1.630	14.23
H_2O	18.02	1.00	1.333	3.71
Thaumasite	622.81	1.87	1.496	97.29
OH	according to Eisenlohr, 1912			2.63
O''	according to Eisenlohr, 1912			2.21
H'	according to Eisenlohr, 1912			1.10

Two hydroxyl groups replace one atom of oxygen, so that for purposes of calculating molecular refractivities the formulas may be respectively considered as:

$\text{CaCO}_3 \cdot \text{CaSiO}_3 \cdot \text{CaSO}_4$ less 2 O plus 4 OH.13 H_2O and

$\text{CaCO}_3 \cdot \text{CaSiO}_3 \cdot \text{CaSO}_4$ less 1 O plus 2 OH.14 H_2O .

The proposed solution of the problem of the relative proportion of hydroxyl and of water rests on the fact that the molecular refractivity of water is 3.71, while the sum of the molecular refractivities of two hydroxyls less one oxygen, which replace the molecule of water in the above formulas, is 3.05, since the value for

⁶ Eisenlohr, F.: *Spektrochem. Org. Verb.*, Stuttgart, 1912, p. 48.

⁷ Specific gravity: 1.88 (Penfield), 1.877 (Lindström), 1.85 (Schaller); refractive indices: ω 1.503, ϵ 1.467 (Bertrand), 1.505 and 1.468 (Brown), 1.507 and 1.468 (Levy and Lacroix), 1.519 and 1.476 (Penfield).

oxygen varies according to its state of combination. Therefore, the values of the molecular refractivity, as given in Table II, for each of these constitutions, differ noticeably; and the calculated value which agrees most closely with the actual value for thaumasite, as given in Table I, represents the most probable constitution. The mean index of refraction, as calculated from these values of the molecular refractivity and the specific gravity of thaumasite by means of the Lorentz-Lorenz formula, are given in the third column, and, for the sake of comparison, corresponding values for a molecule with fifteen waters and no hydroxyl are given.

TABLE II

Constitution	Calculated molecular refractivity	Calculated refractive index
$\text{CaCO}_3 \cdot \text{CaSiO}_3 \cdot \text{CaSO}_4 \cdot 2 \text{O} + 4 \text{OH} \cdot 13\text{H}_2\text{O}$	96.59	1.492
$\text{CaCO}_3 \cdot \text{CaSiO}_3 \cdot \text{CaSO}_4 \cdot \text{O} + 2 \text{OH} \cdot 14\text{H}_2\text{O}$	97.25	1.496
$\text{CaCO}_3 \cdot \text{CaSiO}_3 \cdot \text{CaSO}_4 \cdot 15\text{H}_2\text{O}$	97.91	1.500

The value of the refractive index calculated for the constitution with fourteen molecules of water agrees so closely with the observed mean value for thaumasite (1.496) as to strongly confirm Merwin's results, and incidentally also Wherry's interpretation of the mineral as a sulfate.

BOOK REVIEW

DETERMINATIVE MINERALOGY. CHARLES H. WARREN. 163 pages. McGraw-Hill Book Co., New York, 1921.

The purpose for which this book has been published, as stated in the preface, is a very good one, namely to supply the student with a relatively inexpensive determinative text. Whether the additional requirement of its being a satisfactory one has been met the reviewer is not so certain. The plan of the book is the usual one, comprising a description of the use of the blowpipe, a list of tests for the elements, tabulated lists of special tests and a series of tables in which groups of minerals are eliminated one after another until the one under investigation is located.

The first chapter, on the blowpipe, is thoro and should be helpful to the student. Some may not like the style in places, especially in such arrangements of terms as "Decomposition of insoluble (in acids) minerals" (p. 14); the use of inches on some pages and centimeters on others; the calling of the same thing interchangeably and without explanation a gypsum, plaster, or plaster of Paris tablet, and so on. The English is not always correct, as for example, "All white oxide sublimates are volatile in the R. F. although some (tin) is difficultly so." (p. 12.)

In the second chapter the usual tests for the elements are given. Some objectionable features occur in the use of chemical terms. Thus "glucinium" is given on pages 28 and 41; Fl is used as the symbol for fluorine in places; and niobium is preferred to columbium in spite of the fact that every American chemist sees in the former name merely a German attempt to discredit American chemical research. Over half the atomic weights are stated inaccurately. Phosphoretted hydrogen (p. 53) is an obsolete term. There are also instances of obscure statement, as for instance "the solution filtered (this is yellow if chromium is present)" (p. 37), which should read, the filtrate is yellow; "without practically altering the state of oxidation" presumably meaning without seriously or essentially altering it; "minerals containing fluorine and hydroxyl water also give off acid water" (p. 74) from which the first water would better be omitted. There is a definite element of danger in the sequence of two sentences on page 55: "several rare earth minerals . . . are easily decomposed by strong sulphuric acid. A small excess of ammonium hydroxide is now added to the hot solution. . . ."

No mention is made of the easy test for cerium consisting in adding a pinch of red lead to the nitric acid solution, boiling and allowing to settle; cerium then yields an orange colored solution. Test 1 for tellurium is not, as stated, reliable; for manganese may give a purple color in sulfuric acid, a fact which has even led to loss of money in investments in companies floated to mine "tellurides" the existence of which had been inferred from this test, whereas the ores were really manganese oxides. Under manganese no mention is made of this coloration nor of the green flame color this element yields when its compounds are moistened with HCl.

The last chapter, on the determination of minerals, is of course the most important in deciding the satisfactory character of the book. The general plan seems to be adequate, altho a little more use might be made of colors as a means of division into groups. Since the finger nail scratches gypsum of hardness 2 readily, it might better be assigned the hardness of 2.5. On page 119 chalcantite is indicated as becoming magnetic B.B.; on page 124 it is implied that a coating of ZnO can be obtained from zincite without the use of soda and carbon, whereas it is the reviewer's experience that students have a hard time getting any coating from this mineral even with the use of these; and it hardly seems correct to include wernerite (p. 134) in the list of those harder than glass.

The indexes of scientific books are usually open to criticism for being incomplete; but in this case the reverse seems to be the case, for a considerable number of mineral names are given, often tho not always as synonyms, which do not appear in the text at all, as for instance anatase, desmine, magnetic pyrite (s), molybdate (mineral), pennine, etc. There are however, also omissions, as magnesium oxide (p. 149), molybdite (p. 124), and tin sulfides (pages 108 and 110).

The formulas given for minerals, thruout the book, are in some cases not up to date, in others quite erroneous. As examples may be cited jamesonite, given as $2\text{PbS} \cdot \text{Sb}_2\text{S}_3$; sylvanite, $(\text{AuAg})\text{Te}_4$; polydymite, Ni_4S_6 ; fayalite, FeSiO_4 , molybdite, MeO_3 ; etc. There is also a curious lack of consistency in the use of chemical terms; thus Sb_2O_3 is variously described as oxide of antimony, antimony trioxide and antimonous oxide; As_2O_3 with the additional variation to arsenious oxide; SeO_2 as selenium, selenous, and selenious oxide; and others. The prize in this respect seems to belong to tourmaline, which is mentioned about five times with a different statement of its composition each time, including a borosilicate of Al, etc., complex

silicate of Al and other bases with boron, and boro-aluminium silicate. Phosphorus has added o but once in the book, but aluminium appears both with and without the second i.

A feature likely to be particularly confusing to the student is the indiscriminate use of periods, commas, + signs, and no sign at all to set off the various parts of formulas. Thus on a single page (119), water of crystallization is shown in four different ways, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{MgCl}_2 \cdot \text{KCl} \cdot 6\text{H}_2\text{O}$, $\text{MgSO}_4 \cdot \text{KCl} \cdot 3\text{H}_2\text{O}$ and $\text{Al}_2(\text{SO}_4)_3 + 18 \text{H}_2\text{O}$. Isomorphous replacement (called on page 94 isomorphoric) is indicated by commas in some places, as $(\text{Fe}, \text{Mn})\text{WO}_4$, but by lack of them elsewhere, as $(\text{ZnMn})_2 \text{SiO}_4$ and then unfortunately both plans are also used to show non-isomorphism as in $\text{K}(\text{Fe}, 20\text{H})_3(\text{SO}_4)_2$ and $\text{BiO}(\text{Bi}2\text{OH})\text{CO}_3$.

Some cases of peculiar spellings may be intentional, as asbestose for asbestos, duodecahedral (also appearing as doudecahedron) for dodecahedral (also used once), blend for blende, etc. But mineralogy (p. 95), melelite (p. 140 twice) and pargonite (p. 145) are not. The last belong to the almost incredible number of compositors' errors present. The reviewer has counted over 200 of these (more than one per page) and sees more every time he looks at the book. There are numerous instances of the subscript numerals in formulas being wrong; of capital initial letters where lower case would have been preferable; and of omitting, transposing, and inserting letters. There has evidently been some misunderstanding with respect to correcting proof. The composition must have been done by operators unaccustomed to chemical work; that the publishers did not go over the proof is indicated by the fact that every time one of their own books is mentioned, there is an error either in its title or its author's name; but apparently the author assumed that proof reading had been done. It is to be hoped that the book will soon be reprinted after all of these errors have been corrected.

W.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, Nov. 10, 1921.

A meeting of the Society was held on the above date, President H. W. Trudell presiding. Nineteen members and sixteen visitors were present. Thru the courtesy of the Bureau of Mines at Pittsburgh, six reels of moving picture films were exhibited. The subjects illustrated were: "The Story of Sulphur" and "Zinc Mining, Milling and Smelting;" both of which proved very interesting and instructive.

Mr. Hoadley reported upon the following trips: rutile was found at 274th St., New York; tremolite and brown tourmaline were secured at the old dump at the Harlem River canal; while a visit to the locality of Ossining yielded specimens of azurite, serpentine, pyrite, malachite, and mountain leather. Prehnite, pseudomorphous after stilbite was also reported from Paterson.

At a new Perkiomenville quarry, Mr. Hilbiber found calcite crystals covered with pyrite. He also exhibited specimens of epidemine from the Kibblehouse quarry.

Mr. Knabe reported having taken a trip to the DeKalb St. quarry where calcite crystals were found. These crystals were in the form of short hexagonal

prisms, up to 2 cm. in diameter, capped by rhombohedrons. Several other quarries at Port Kennedy and vicinity were visited but with negative results.

JOHN FRANKENFIELD, *Secretary pro tem*

NOTES AND NEWS

Under the title "Research Problems in colloid chemistry," Professor Wilder D. Bancroft has recently published a list of 200 subjects in which investigation is needed (*J. Ind. Eng. Chem.* **13**, 83, 153, 260 and 346, 1921; *Reprint & Circ. series, Nat. Res. Council*, No. **13**, 1921.). The following are of special interest to mineralogists and crystallographers:

(52) Adsorption and abnormal density: in density determinations by weighing a solid in a solution, an error may be introduced by adsorption of the salt.

(57) Comparative study of adsorption by alumina, silica, kaolin, etc.: determination of relative adsorptions should help in working out the constitution of silicates.

(78) Crystallization of grape sugar as an adsorption phenomenon: the formation of needles in an acid solution and plates in an alkaline one should be studied from the adsorption standpoint.

(79) Crystallization of sodium chloride in cubes and octahedra: should be studied as a case of adsorption.

(90) Production of crystals: large crystals of insoluble substances can be obtained by diffusion of their constituents; more work should be done; it might even be possible to synthesize dolomite thus.

(134) Definition of lusters: "The people who write about gems speak of adamantine, vitreous, oily, waxy, resinous, pearly, silky, and metallic lusters, but there is no adequate definition of any of these terms. Somebody should work out definitions of these terms with reference to the optical properties involved. . . ."

(200) Action of ultraviolet light and of radium on gems; many examples are cited. Apparently the radium increases the dispersity of the colloidal particles, and ultraviolet light decreases it, or vice-versa. It should be possible to test this on synthetic materials, using perhaps borate glasses. Careful study should straighten out the question of the colors of gems.

E. T. W.

On the invitation of the Division of Geology and Geography of the National Research Council, the Council of the Mineralogical Society of America designated Dr. Edgar T. Wherry as the representative of the Society in that Division.

Contributors to *THE AMERICAN MINERALOGIST* will be pleased to hear that arrangements have now been effected whereby they will be given twenty-five copies of the issue containing their article. If additional reprints are desired these can be purchased at the prices listed on the inside cover of this magazine.

The new periodical, *Bulletin Suisse de Minéralogie et Pétrographie*, which in spite of present difficulties was founded a year ago with a view of centralizing publications of all work relating to the mineralogy and petrography of Switzerland, has now completed its first volume (comprising 412 pages). The subscription price is 25.—Swiss francs per annum, payable to the editor, Dr. U. Grubenmann, Sonneggstr. 5, Zürich 6.

ABSTRACTS—MINERALOGY

MICROSCOPIC INVESTIGATIONS OF SMALTITE AND CHLOANTHITE. A. BEUTELL. *Centr. Min. Geol.* **1916**, 206-221.

Investigation with the metallographic microscope showed the presence in "smaltite" of three easily distinguished arsenides, CoAs_3 , Co_2As_5 , and CoAs_2 . The outer shell of smaltite crystals is of CoAs_2 which determines its isometric form. The isometric crystals of skutterudite may be pseudomorphs of CoAs_3 after CoAs_2 .

EDW. F. HOLDEN.

A SYNCHRONOPHOSPHOROSCOPE. E. L. NICHOLS AND H. L. HOWES. *Phys. Rev.* **7**, 586, 1916. THE PHOSPHORESCENCE OF URANYL SALTS. E. L. NICHOLS. *Proc. Am. Nat. Ac.* **2**, 328-333, 1916. PHOSPHORESCENCE AND ABSORPTION OF CERTAIN URANYL SALTS. E. L. NICHOLS AND H. L. HOWES. *Phys. Rev.* **8**, 364-385, 1916; thru *Neues Jahrb. Min. Geol.* **1919**, Ref. 20.

These papers contain data of interest in connection with luminescent minerals.

E. F. H.

TELLURIUM FROM RUDA, IN THE ERZGEBIRGE. F. BERWERTH, *Mitt. Wiener Min. Ges.* no. **79**, 54-55, 1916; thru *Neues Jahrb. Min. Geol.* **1919**, Ref. 273.

What was formerly thought to be stibnite was found to be tellurium, the occurrence being in calcite, the crystals of tellurium being up to one cm. in length.

E. F. H.

CHANGES IN THE ABSORPTION OF PLEOCHROIC CRYSTALS AT THE TEMPERATURE OF LIQUID AIR. H. NAGAOKA. *Proc. Math.-Phys. Soc. Tokyo*, **8**, 551-554, 1916; thru *Neues Jahrb. Min. Geol.*, **1919**, Ref. 19-20.

The changes in the pleochroism of epidote and penninite with decrease in temperature were marked.

E. F. H.

THE DETERMINATION OF THE DENSITY OF SOLIDS. H. LE CHATELIER AND F. BOGITCH. *Compt. rend.*, **163**, 459, 1916; thru *Neues Jahrb. Min. Geol.*, **1918**, Ref. 118.

The error in density determinations due to air bubbles adhering to the substance investigated may be avoided by the use of carbon tetrachloride in place of water.

E. F. H.

THE TRANSFORMATION OF Na_2SO_4 . E. JÄNECKE, *Z. phys. Chem.*, **91**, 548-569, 1916; thru *Neues Jahrb. Min. Geol.* **1918**, Ref. 25.

Besides the recognized transformation at 240° , Na_2SO_4 passes thru a second at 385° .

E. F. H.

THE EXCHANGE OF BASES IN SILICATES. I. EXCHANGE OF ALKALIES AND AMMONIA IN THE HYDRATED ALUMINUM-ALKALI SILICATES (PERMUTITES). E. RAMANN AND A. SPENGEL. *Z. anorg. Ch.* **95**, 115-128, 1916; thru *Neues Jahrb. Min. Geol.*, **1918**, Ref. 252.

Sodium, potassium, and ammonium permutites pass over into one another thru the exchange of their bases by the action of chloride, nitrate, or sulfate solutions.

E. F. H.